ESTIMATING THE IMPACT OF LANDFILL PROXIMITY ON THE VALUE OF REAL ESTATE GOODS

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Abstract
A part of the net benefit from goods consumption is determined by their environmental characteristics. The size of the benefit depends on the properties of the goods, but also on how these are perceived by consumers. Therefore estimating environmental benefits allows, on the one hand, environment's monetization, and on the other hand to formulate opinions about awareness regarding environmental issues and their impact on individual wellbeing. Departing from these facts, the paper aims to measure the environmental benefits of a real estate goods consumer, realizing an estimation of incompliant landfills (ICL) proximity's impact on the value of these goods. For estimation, it was used the method of hedonic pricing and were processed regarding Bucharest periphery. Providing quantitative information regarding the importance of ecological criteria in the procurement of real estate goods, verification of the relevance of available estimations for Romania and the identification of the model that explains the impact of ICL on the value of real estate goods are the main contribution brought to knowledge development. In fact, the results obtained are aligned with the results of similar assessments made in Europe, indicating that 31,2% of the variation of real estate goods' value is determined by the proximity of landfil. Studies regarding the relation between the size of variation and the development level could contribute to increase the relevance of these results for other regions of Romania.

Keywords: environmental benefits, hedonic prices, landfill, real estate goods, Bucharest periphery

JEL Classification: Q51, Q53

Introduction

Consumption of products and services represents the very heart of economic system's functioning. This fuelled economic growth and development for decades, being stimulated by more and more refined techniques – advertising, fashion, luxury, identification of needs with merchandises etc., that are specific for *consumption society* (Bleahu, 2001). In the context of ever growing intensity of ecologic crises – climate change, biodiversity loss, exhaustion of natural resources, accumulation of waste, pollution etc. – the paradigm of

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unlimited needs that could be satisfied by continuous growth and diversification of consumption, respectively production, was opposed to the paradigm of environment's limited resources that are necessary for realizing products and providing services.

Consumers' behaviour is relevant for this subject area from at least two points of view. On the one hand, consumers influence the decisions of goods and services producers by their preferences, transmitting ecological requests for both the quality of products and services and the way of their production (Najam et al., 2006). On the other hand, the analysis of consumers' behaviour allows the estimation of the monetary value of environmental externalities, which, in the context of cost-benefit analysis, is interpreted as a measure of environmental benefits (EC, 2008; Boardmann and Greenberg, 2004; Rojanschi et al., 2003).

The paper approaches this second aspect, pursuing to determine the environmental benefits of a real estate goods consumer. In this respect, it is applied the methodology of hedonic pricing, which is recognized as the most appropriate tool for this type of assessments (EC, 2008, Taylor, 2003; Rojanschi et al., 1997; Palmquist, 1991). There are processed empiric data for real estate goods in Bucharest periphery. The outcomes are relevant for the ecological behaviour of consumers by the fact that they provide quantitative information regarding the importance of ecological criteria for the purchasing of a category of goods. Through the comparison of these results with other assessments there could be made inferences about the level of environmental awareness in Romania against other countries.

The paper's structure comprises a brief presentation of the hedonic pricing method, followed by a review of the results of its application for analyzing the relations between landfill proximity and property values, the application of environmental benefits estimation and interpretation of results, ending with a number of conclusions.

1. Hedonic prices – general applicability

For resources allocation decisions to be based on economic value, the net economic benefits of a good or a service should be measured. This is given by what people are willing to pay additionally to what they actually pay. Thus, two goods sold for the same price could have different net benefits. The net benefit is given by adding up consumer's surplus (figure no. 1-A) with producer's surplus (figure no. 1-B).

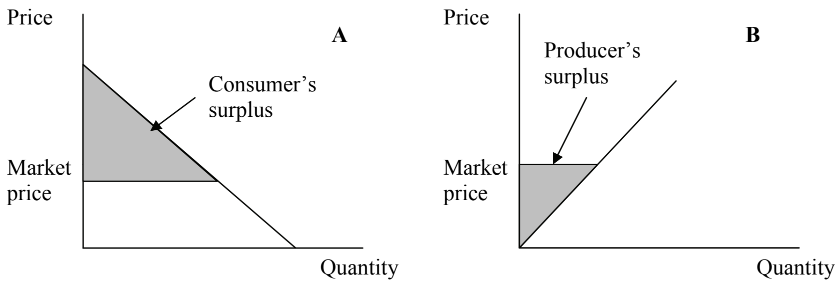

Figure no. 1: Consumer's (A) and producer's (B) surplus

Benefits determined by the environmental characteristics of a good, further indicated as environmental benefits, could be approximated, estimated, without being possible a very exact quantification. This approximation is considered to produce, generally, an underestimation, being considered a “dilution” of the value (Kuuluvainen, 2002).

Estimation of environmental benefits is performed using a variety of methods and techniques, such as: travel costs, hedonic pricing, abatement costs, contingent evaluation, choice modelling etc. These are completed by a number of methods and techniques that use secondary data such as value/benefit transfer and meta-analysis techniques. Although each method is advantageous in a certain context, there are also typologies of them. Availability of market prices (figure no.2) and how preferences are expressed are the most well known criteria used for grouping environmental benefit estimation methods.

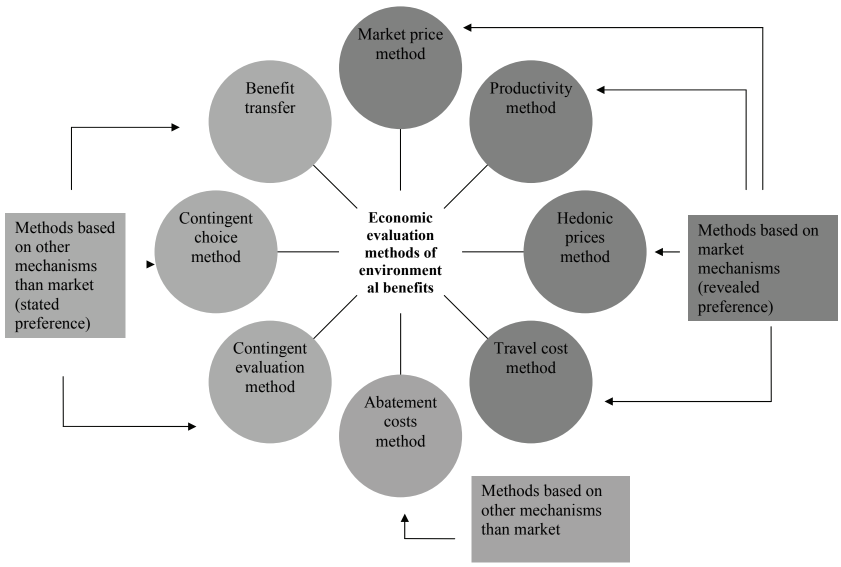

Figure no. 2: Methods and techniques for the quantification of environmental benefits

The method of hedonic prices assigns values to environmental benefits by estimating the statistic relation between the attributes of the evaluated system and another good or service for which a market value exists.

The hedonic value models of properties suppose that individuals perceive housing units as a sum of attributes and that they derive different utility levels from different combination of these attributes. Then transactions are made, individuals compare prices and attributes and decide in accordance with the marginal value of these attributes. After Bartik (1987), the hedonic value model is built in two stages:

- Selling prices are decomposed for estimating implicit prices of each characteristic, and further the function of hedonic prices. Estimates provide marginal prices, respectively prices that are to be paid by a buyer for little changes of the characteristics (e.g. increase of distance from a noise source by one kilometre or increasing proximity to a forest by one kilometre). Generally, there are used data regarding a single situation, most of studies performing only this stage;

- Application of a number of restrictions for the utility function in order to obtain value estimates, and further the demand function. Generally, there are used data regarding more real estate markets.

For the method to be applied there are collected data regarding property values on an existing real estate market. The price of a house or a plot becomes the dependent variable on the structural characteristics of the house, characteristics of neighbourhoods and environmental quality, respectively benefits expected by buyer. Necessary conditions are the existence of active markets, people to be aware of environmental benefits, changes in environmental quality to be perceived by population, and no distorted markets with transparent transaction.

Analyzes could be complicated by a number of factors. For example, the relation between price and property characteristics could not be linear – prices could rise with larger or smaller rates than the rate of change in characteristics. In addition, numerous variables are correlated, fact that could lead to the underestimation of the significance of some variables.

The hedonic price method has a high credibility mainly because it uses revealed preferences of consumers and good availability of data regarding real estate properties. These data are used in the calculation of taxes.

The method is applied for the estimation of environmental benefits, respectively costs associated with the proximity of existent or future objectives. The distance to these objectives (proximity) are correlated with the price, but also with the intensity of the objective's influence on environmental quality. For example, the esthetical value of a lake decreases with the increase of property's distance to the lake. Most of the studies report results for the proximity of objectives such as forests (Tyrvainen, 1997; Garrod and Willis, 1992); airports (Cohen and Coughlin, 2010; Lake et al., 1998); rail roads (Strand and Vagnes, 1997); landfills (Ready, 2005; Ascari and Cernuschi, 1996; Kiel and McClain, 1995); power grids (Bateman and Lake, 1995).

2. Results of hedonic analyzes for landfills

Landfills are one of the few environmental issues that have symptoms perceived unequivocally by public (Pleşea and Vişan, 2010; Calabro and Contri, 2007), even if there are differences in the impacts interpretation (focusing on health, discomfort, or other features). According to BDA Group (2009), the most significant components of external costs for landfills are greenhouse gas emissions and the discomfort created by the landfill's proximity. Generally, this discomfort is due to odour emissions, lower aesthetic value, debris brought in by wind, presence of insects and rodents, noise and vibration determined by the functioning of installation and waste transportation (Pleşea and Vişan, 2010; Walton et al., 2006; Rojanschi et al., 2002).

Determining the economic value of discomfort produced by the presence of landfills represented a subject approached by numerous researchers, starting with Havlicek et al. (1970), who analyzed the impact of landfills from Fort Wayne (Indiana) on the value of properties. A great part of these studies are made in North America, assessments being done at Minnesota (Nelson et al., 1997; Nelson et al., 1992); Baltimore (Thayer et al., 1992); Columbus (Hite et al., 2001); Toronto (Lim and Missios, 2003).

In the European area, there were also made numerous assessments. The most comprehensive ones are the ones initiated by the European Commission (EC, 2000) and the Department for Environment, Food and Rural Affairs from Great Britain (DEFRA, 2003). EC (2000) is a study that makes calculations for the European situation using results obtained in US. DEFRA (2003) outstands by the large amount of data that refer to 11,300 landfills and 592,000 properties. Existing estimates, and own empiric results are comprised in a meta-analysis by Ready (2005). As long as Romania is regarded, empirical results are scarce, studies being limited to the requirements of cost-benefit analysis for investment projects.

Generally, results of empiric studies confirm the negative impact of landfill proximity on property values, but there are also exceptions such as those reported by Bouvier et al. (2000), Zeiss and Atwater (1989) and Gamble et al. (1982). The lack of statistic relation was explained by sampling issues (Ready, 2005).

From one study to another there are differences regarding the intensity of the impact, results being site specific. Moreover, the possibility to use benefit transfer is considered very limited (Eshet et al., 2006; Ready, 2005). Most frequently results are expressed as gradient of value decrease with the increase of proximity or as loss of value (absolute or relative) at a certain distance. Proximity is measured by the distance from landfill to property, but there are studies that use the inverse of the distance or the natural logarithm of the distance.

Variation in the value of properties is comprised within wide limits, differences being determined by the size of landfills (Ready, 2005), development level and value of properties (Walton et al., 2006) and the incomes of proprietors/buyers (Nelson et al., 1997). For example, in case of landfills with large flows of waste (over 500 tones per day) value of land drops with 12.9%, while for small deposits the decrease is of 2.5% (Ready, 2005). DEFRA (2003) shows that the value loss could reach 40%, situation noticed in Scotland. Most of the studies signal that the regression between the proximity and prices could be made within a limited perimeter, situated at 3-5 kilometres from the deposit.

3. Evaluation of landfill proximity's impact on environmental benefits

The study departed from the premise that land and houses are the most common goods supposed to hedonic analyzes. The basic hypothesis of the analytic model developed further is that for two properties with identical characteristics (built area, surface of the area around the house, number of bedrooms etc.), excepting the fact that one is near an incompliant landfill (that does not respect the provisions of HG nr.349/2005, regarding waste deposits, ICL), and the other is further. The prices of the two properties are compared, and the price difference is interpreted so that the more expensive has more environmental benefits. For example, if the property that is close to the ICL costs 100,000 euro, and the other costs 150,000 euro it could be said that closing the ICL would bring to the proprietors of the cheapest house a 50,000 euro benefit.

The analytic model to be developed a set of empiric data is obtained by 50 statistic records. The observed unit was represented by the considered real estate with the following characteristics: price of the property, distance from the ICL, built area, surface of property around the house, number of rooms and bathrooms, existence of garages, utilities, internal endowments (sandstone paving, parquet, heating installation, fire place, air conditioning) and backyard arrangement (terraces, trees, flowers, swimming pool, walking ways). The units for the observation base were represented by properties situated on Fagului, Ariei, Frumoasa, Putul cu brad, Poieni streets from Mogosoaia village, streets that are situated close to a ICL which is in enclosing process. The data were collected by direct observation, through field operators.

Property's distance from ICL should have an influence on its price. Simple regression is used then between the two characteristics a linear or nonlinear dependence exists, but by different transformation could be brought in the shape of a linkage for which parameters could be expressed. Within this model we will note by Y the price (dependent variable) and with X the distance from the ICL (explanatory variable). Based on the graphical representations there are formulated hypotheses regarding the linear or nonlinear shape of the dependence of Y price from recorded X factor. The testing of these hypotheses was made based on the least square method.

In case that the linkage between the two variables is linear we will said that the price of the property is linear depending on its distance from ICL. Since the dependent variable is also influenced by a number of random factors, unquantifiable, we will consider the probabilistic model of dependence analysis, written in the form $Y = a_0 + a_1 X + \varepsilon$, where ε is the random variable, and $a_0, a_1 \in R$ are the parameters of the regression model. In case that the dependence is appreciated as a parabola of second degree, the regression model has the shape of $Y_x = a_0 + a_1 x + a_2 x^2 + \varepsilon$. Departing from the conditions of the $\sum\left(y - \hat{a}_0 - \hat{a}_1 x - \hat{a}_2 x^2\right)^2 = 0$ test, the function's parameters are determined. In case that the dependence is appreciated as a hyperbole, the regression model takes the form of $Y_x = a_0 + \frac{a_1}{x} + \varepsilon$, in case of a logarithmic relation, its form is $Y_x = a_0 + a_1 \lg x$, and in case of an exponential relation, the model form is $Y_x = a_0 a_1^x$. The values of regression function parameters are presented in table no.1.

Table no. 1: Estimated values of regression functions parameters

Type of the model	$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_2$
linear	118.235	15.335	-
parabolic	121.4	12.9	0.32
hyperbolic	207.76	-78.39	-
logarithmic	128.03	42.7	-
exponential	119.56	0.087	-

Source: own calculations

The parameter which is of interest for us in this analysis is the one that correspond to the distance of the property from the ICL. Considering, for instance, the linear model written as $Y = 118{,}235 + 15{,}335X$, it could be concluded that *if it is to depart from the ICL and* *go away with one kilometre the value of the properties increases with 15,335 euro*, based on the hypothesis of a linear relation between the analyzed variables. We mention the fact that the results of the proposed model are conclusive only for some distances from the ICL. The price difference between properties situated at 10 kilometres and another at 15 kilometres from the ICL will not be necessarily of approximately 45 thousands euro. The results could be conclusive only in cases in which the considered environmental effects are expressed. Similar interpretations are obtained by changing the hypothesis on the linkage among analyzed variables. The attention is focused on parameter $\widehat{a}_1$, which suggests an increase of properties value along with the increase of the distance from the ILC.

We are developing the analysis for studying the hedonic price through the interaction of property's distance from ICL and the area around the house, being obvious the fact that the environmental effects of ICL impact more on surrounding. In this case, the shape of the regression model is $Y = a_0 + a_1X_1 + a_2X_2 + \varepsilon$. For determining a_0, a_1 şi a_2 the least squares method was used, by minimizing the $\sum_{i}^{n}(y_i - a_0 - a_{1i} - a_2x_{2i})^2$ function, where $\left((y_i, x_{1i}, x_{2i}), i = \overline{1,n}\right)$ represents the series of recorded values. By processing, the parameters of the regression function have the fallowing values: a_0=99,5; a_1=13 and a_2=0,05. Therefore, the regression equation will be: $Y = 99{,}5 + 13X_1 + 0{,}05X_2$. Thus, *if it is to depart from the ICL and go away with one kilometre the value of the properties will increase, on average, with 13,000 euro, as long as the area around the house is also of interest. However the area of the backyard induces an increase of properties value with only 50 euro, which strengthens the conclusion that the distance to ICL determines the strongest influence on the value of properties considered in the study.*

In the analysis it is included as independent variable the area of the house. Generally, the regression model is written as matrix $Y = X\beta + \varepsilon$, where $Y \in M(T,1), X \in M(T,p), \beta \in M(p,1)$. For the estimation of the parameters the following hypotheses were tested:

H1: exogenous variables are not collinear. We could say that there are no real non null numbers $\lambda_1, \lambda_2, ..., \lambda_p$, for which $\sum_{t=1}^{p}\lambda_i x_{it} = 0, t = \overline{1,T}$. If $X_1, X_2, .X_3$ variables are collinear, when $\lfloor XX^t \rfloor = 0$. In this case, the X matrix is reversible and the models parameters cannot be estimated.

H2: The random variable ε satisfies hypotheses and $V(\varepsilon) = E(\varepsilon\varepsilon^1) = \sigma^2 I$. $\varepsilon_t, t = \overline{1,T}$ variables have the same variance and are not correlated. We will say that there is homoschedasticity and there is no phenomenon of errors autocorrelation. In most cases it is considered that ε follows a normal T dimensional distribution.

Consequently $\widehat{Y} = Xa$, applying the least squares method it is obtained that $a = (X^TX)^{-1}X^TY$. The $(X\ X1)^{-1}$ matrix exists since $X_1, X_2, ..., X_p$ are linearly independent. Thus $a = (X^T X^{-1}) X^T (X\beta + \varepsilon) = \beta + (X^T X)^{-1} X^T \varepsilon$. By processing empirical data with SPSS, *the parameter of the variable of interest is 13,245*, its interpretation being similar to the previous case.

The analytical model is further developed by appreciating the intensity of the relation between properties' prices and distance to the ICL (table no.2).

Table no. 2: Values of determination and correlation ratio in case of simple linkages

Type of the model	Value of determination ratio	Value of correlation ratio	Standard error of estimation
linear	0.303	0.551	50.377
parabolic	0.304	0.551	50.897
hyperbolic	0.202	0.449	53.918
logarithmic	0.269	0.519	51.602
exponential	0.312	0.558	0.281

Source: own calculations

Simple linkages established between property prices and distance from ICL, regardless to the model that is used, support the supposition made initially, but the linkages are not very strong. The exponential model explains most of property prices variations (31%) against their distance from the ICL. In fact, this proved to be the most appropriate estimation model for the analyzed simple linkages, having the lowest estimation error.

In case of multiple models the problem of measuring the intensity of relation between variable supposes two approaches: dependence from all independent variables (table no.3) and partial dependence (table no.4).

Partial correlation ratios, respectively the determinant coefficients for measuring the degree of dependence for the resulting variable from each of the recorded factorial variables are the statistical measures based on which the partial dependence of analyzed property prices are characterized.

Table no. 3: Values of determination and correlation ratios in case of multiple linkages

Type of the model	Value of determination ratio	Value of correlation ratio	Standard error of estimation
Bi-factorial	0,486	0,697	43,739
Tri-factorial	0,628	0,792	37,62

Source: own calculations

Table no. 4: Value of determination and correlation ratio

Type of the model	Dependence from	Value of partial correlation ratio
Bi-factorial model	Properties distance from ICL	0.551
	Area around the house	0.523
Tri-factorial model	Properties distance from ICL	0.551
	Area around the house	0.523
	Area of the house	0.480

Source: own calculations

Considering the determination ration calculated for the bifactorial model we reach to the conclusion that property's distance from ICL in interaction with the area around the house explains almost half of price variation for the analyzed properties, each one of the two factors having a direct influence on the increase of the prices with a mild intensity. The degree of explanation for price rising, along with getting away from ICL, increases by considering the area around the house in the analysis. Thus it is explained 60% of property prices variation, conclusion that is reached by considering the determination ratio calculated on the base of the trifactorial model. The rest is considered to be determined by other characteristics of properties, which were not included in the models' construction: number of rooms and bathrooms, existence of garages, utilities, interior endowments (sandstone paving, parquet, heat installation, fire place, air conditioning) and backyard arrangement (terraces, trees, flowers, swimming pool, walk ways).

It would be expected that the area around the house to be the most important influence factor for property price. By analyzing the partial correlation ratio values, presented in table no. 4, it is noticed that the distance to ICL represents the determinant factor for the price variation of analyzed properties, its value being of 0.551.

Environmental benefits brought by enclosing the ICL and the neutralization of its effects are measured in monetary terms for each of the individuals that would benefit the qualitative improvements of environmental elements in the immediate vicinity. The interaction between the distance from the ICL, area of the house and of the backyard give 62.8% of price variation for real estates in the analyzed area, the most important influence factor being the distance from the ICL.

Conclusions

Evaluation of benefits obtained by a consumer by buying ecological goods represents an important action for obtaining information about motivations, and it could be interpreted as a measure of environmental awareness, respectively of the relation between environmental quality and consumers' wellbeing. The paper contributes in this direction by realizing a hedonic analysis regarding the benefits of decreasing real estates proximity to an incompliant landfill in the periphery of Bucharest.

Hedonic analyzes were applied for the estimation of landfills' proximity impact on the value of real estate goods since 1970s. Their results indicate that it is a negative impact, the value of real estate goods decreasing along with the increase of landfill proximity. On the other hand, the size of the impact is different depending of the analyzed area (Eshet et al., 2006; Ready, 2005). Thus, for the European space, the value variation is comprised between 12.9 and 40% (Walton et al., 2006; Ready, 2005; DEFRA, 2003; EC, 2000), meaning an decrease of properties' value situated at approximately 0.5 kilometres from a landfill against the ones situated at 3.0 kilometres.

The results of hedonic analysis for the Bucharest periphery consist in the identification of the impact type, estimation of its *size* and indication of the most appropriate model for the analysis of the impact. The proximity of ICL has a *negative* impact on the value of real estate goods that is manifested by a price variation of 15.335 euro per kilometre, and 13.000 euro per kilometre if the area around the house is considered too. In fact, by considering the most true estimation model of real estate goods value in the proximity of

ICL it could be appreciated that *31.2%* of their value variation is given by the distance against ICL. The undergone statistic analysis suggests the use of *exponential* model for the study of the variation of landfill proximity real estate good's value as being the model with the smallest estimation error.

The 31.2% variation of real estate goods value due to the proximity of ICL is comprised with the limits identified by other studies for landfills situated in Europe, respectively between 12.9 and 40.0%. Therefore, we could consider that literature provides guiding data regarding the impact of landfill proximity on the value of real estate properties in Romania.

The results of this study could contribute to the estimation of environmental benefits in case of ecologic (compliant) landfill projects, since they provide a quantitative milestone that could be compared with the impact of these landfills on the value of real estate goods. Meanwhile, the study could be multiplied in the case of other ICL from Romania in order to identify and assess the factors that influence the size of proximity impact on the value of real estate goods.

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